

Long-term operation of combined heat and power in a small hospital

Royal Hospital for Neuro-disability



- Successful long-term operation, reliability and cost-effectiveness
- Savings for the hospital of £33,500 over 8.4 years with no capital outlay
- Capital investment provided by Energy Services company
- Simple payback of 3.2 years for an equivalent capital purchase scheme



ARCHIVED DOCUMENT

ENERGY EFFICIENCY

BEST PRACTICE
PROGRAMME

HOST ORGANISATION



The application of CHP at the Royal Hospital for Neuro-disability in 1985 was an innovation. We understood that a programme of planned maintenance would be required if the plant was to be reliable and this was one of the reasons for us opting for a CEM agreement with BP Energy.

Under the CEM arrangement, BP Energy funded the installation of the CHP and subsequently operated and maintained it. We began to benefit from savings immediately the plant was commissioned and from this point we were interested in its long-term reliability as it had reduced our overall energy costs. We are pleased to look back over the nine-year life of the installation to see that it has given good service and that we have benefited from the savings.

The success of the installation in 1985 has led us to commission a further CHP unit to serve a new wing and part of one of the old wings at the hospital.

A handwritten signature in black ink, appearing to read 'P B Palethorpe', written over a thin horizontal line.

Mr P B Palethorpe
Director of Support Services
Royal Hospital for Neuro-disability

ROYAL HOSPITAL FOR NEURO-DISABILITY

The Royal Hospital for Neuro-disability is a charity which provides, promotes and develops services and treatments for individuals with profound or complex physical disabilities, in particular those resulting from damage to the brain or nervous system. The hospital was built in the second half of the nineteenth century, although the oldest part of the building dates from 1770. The facilities have been extensively refurbished and extended in recent decades.

ARCHIVED DOCUMENT

BACKGROUND

WHAT IS CHP?

Combined heat and power (CHP) is the generation of thermal and electrical energy in a single process. In this way optimum use can be made of the energy available from the fuel. CHP installations typically convert around 80% of the energy in the fuel into electrical power and useful heat. This compares very favourably with conventional power generation which provides electrical power to the point of use at an efficiency of only around 30%.

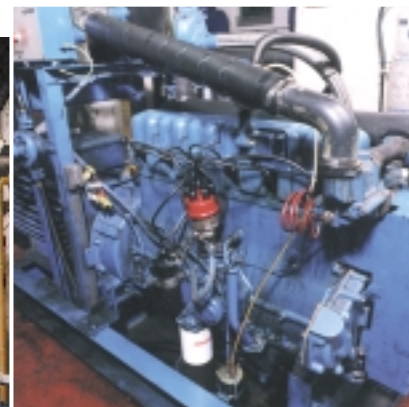
The value of the electricity and heat produced by a CHP unit is greater than that of the fuel consumed. In particular, the value of a unit of electricity can be up to five times that of a unit of fuel. So long as the difference offsets capital and maintenance costs, savings are made. In order to maximise savings from the initial capital investment, running hours should be as long as possible through the use of both electricity and heat.

ROYAL HOSPITAL FOR NEURO-DISABILITY, PUTNEY

The Royal Hospital for Neuro-disability, formerly the Royal Hospital and Home, Putney, has a significant demand for electricity and heat throughout the year, the heat load being space heating and domestic hot water.

In 1985, BP Energy carried out an energy audit at the hospital and established that the site was suitable for a combined heat and power (CHP) installation. The base demand for heat throughout the year is around 200 kW. It was confirmed that this could be provided via a CHP installation which would also supply 80 kW_e electrical output to significantly reduce electricity imports to the site.

Late in 1985, two CHP units, each with an electrical output of 40 kW_e, were installed at no cost to the hospital as part of an Energy Services, or Contract Energy Management (CEM), arrangement with BP Energy. The CHP units were installed in the hospital boilerhouse alongside the existing boiler plant. The boiler plant now only operates to meet the winter space-heating demand.



The two 40 kW_e natural-gas-fired CHP units (inset showing detail)

The project was monitored independently by: The Dyer Warner Partnership.

Tel: 0116 267 6017. Fax: 0116 267 3819.

Energy Services/Contract Energy Management company: BP Energy Limited.

Tel: 01753 585585. Fax: 01753 580366.

There are other suppliers of similar energy services in the market. Please contact the Combined Heat and Power Association (CHPA) for an industry directory (Tel: 0171 828 4077. Fax: 0171 828 0310) or contact ETSU who may be able to provide you with more details.

THE CHP SYSTEM AND PERFORMANCE

THE CHP SYSTEM

The CHP installation (Fig 1) consists of two non-modulating natural-gas-fired units. Design heat recovery capacity is 95 kW/unit. The CHP electrical output is supplied to the hospital in parallel with the incoming mains. The maximum generation of 80 kW_e is always less than the hospital's electrical demand, so there is never any export of power to the local electricity company network.

Heat recovered from the engine cooling jackets and the exhaust heat exchangers is used to supply hot water to the hospital. Connection to the heating system is via a pumped bypass off the boiler return flow pipework. The gas supply to the CHP units was taken from the supply to the boilerhouse and electrical connections were made in the electrical switchroom within the hospital.

CHP SYSTEM CONTROL

Operation of the CHP units is controlled by heat demand. The units are configured to operate as lead and second heat source, the designation being changed over at each monthly service to equalise operating hours. For most of the time both units operate. However, if heat demand falls, the units are

switched off sequentially. When heat demand rises beyond that which can be supplied by the units, the boiler plant is brought into operation.

It is common for small-scale CHP installations to be shut down during the small hours when electricity is cheaper. Time control is normally used to facilitate this. The installation at the hospital has no time control and if heat is required it is economical to operate for substantial periods during the night. The CHP plant at the hospital is not equipped with a computer monitoring and control system which is now standard with modern CHP plant.

CHP PERFORMANCE

The CHP plant has operated since November 1985, and there have been no major breakdowns. As a very general rule, a minimum of 4,500 running hours/year are needed for small-scale CHP to be viable. The number of operating hours logged for each unit confirms near continuous operation for the entire period. The units are nominally set to run 24 hours/day although they are not expected to do so during periods of low heat demand. Operating data since commissioning are shown in Table 1.

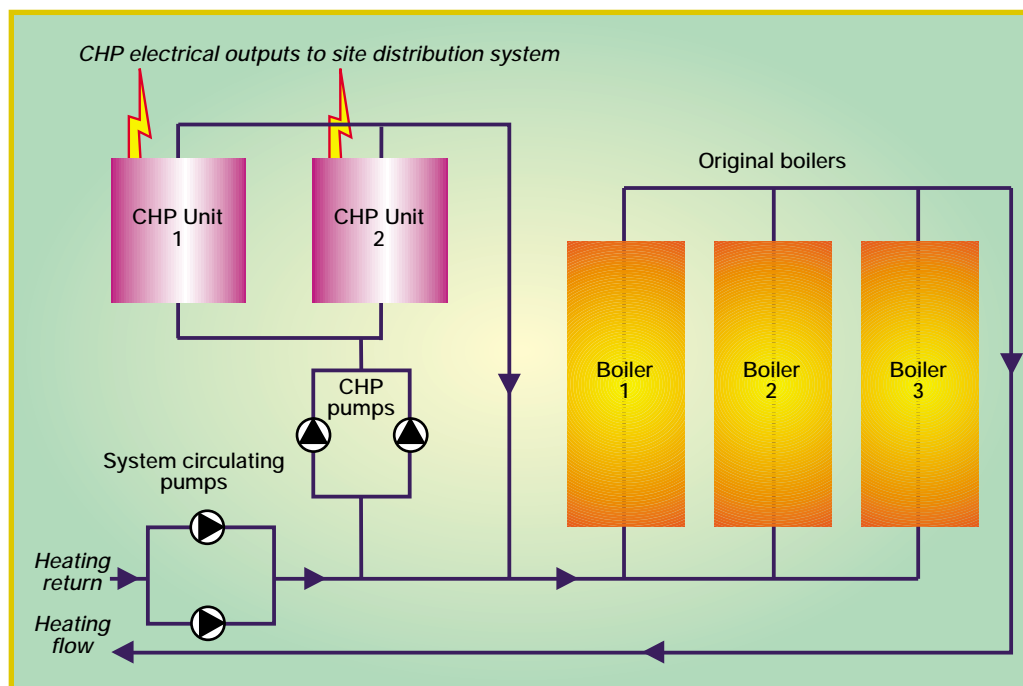


Fig 1 Simplified schematic diagram of CHP/boiler installation

LONG-TERM MAINTENANCE COSTS

Table 1 CHP operating data

| Year | Hours run | | Electricity generated (kWh) | |
|-----------------|---------------|---------------|-----------------------------|------------------|
| | Unit 1 | Unit 2 | Unit 1 | Unit 2 |
| 1985 (2 months) | 1,182 | 1,345 | 47,280 | 53,800 |
| 1986 | 7,291 | 6,718 | 291,640 | 268,720 |
| 1987 | 7,291 | 6,718 | 291,640 | 268,720 |
| 1988 | 7,291 | 6,718 | 291,640 | 268,720 |
| 1989 | 6,277 | 4,624 | 251,080 | 184,960 |
| 1990 | 2,556 | 5,752 | 102,240 | 230,080 |
| 1991 | 6,315 | 8,159 | 252,600 | 326,300 |
| 1992 | 6,617 | 7,040 | 264,680 | 281,600 |
| 1993 | 7,944 | 5,587 | 317,760 | 223,480 |
| 1994 (3 months) | 2,146 | 2,007 | 85,840 | 80,280 |
| Total | 57,568 | 57,637 | 2,196,400 | 2,186,720 |

Utilisation based upon 24 hours/day possible running (8,760 hours/year) has averaged 78% for the installation. As the plant is not computer monitored it is not possible to give accurate data for availability. However, given the utilisation and the excellent plant reliability, availability of the plant is estimated to have averaged in excess of 95%. This is a tribute to the high-quality maintenance regime applied to the plant throughout its life. Monitoring of the CHP plant during the period 9th - 26th August 1994 showed that it performed very near to its design conditions. Thermal output was assessed at 106 kW (slightly higher than the design value of 95 kW) indicating a small loss of engine efficiency. The increase in exhaust heat is to be expected as the engines become due for overhaul. Figs 2 and 3 overleaf show the contribution that the CHP installation has made to the site's energy requirements.

LONG-TERM MAINTENANCE COSTS

The CHP units are maintained according to a planned schedule under the Energy Services arrangement. In earlier years maintenance was undertaken by the manufacturer but it is now sub-contracted to a local

company. Engineers visit the site monthly to carry out the regular maintenance tasks. These consist of a visual inspection for any sign of wear, checking oil levels and setting the sequence controller. The oil is changed every 720 hours of operation and the oil and air filters every 1,440 hours.



Royal Hospital for Neuro-disability

RESULTS

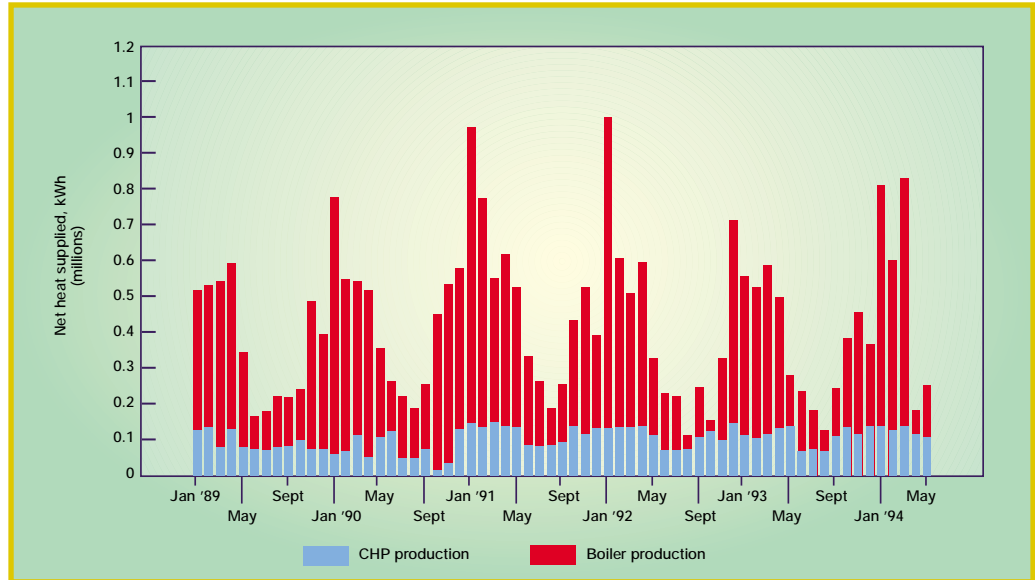


Fig 2 Site heat usage

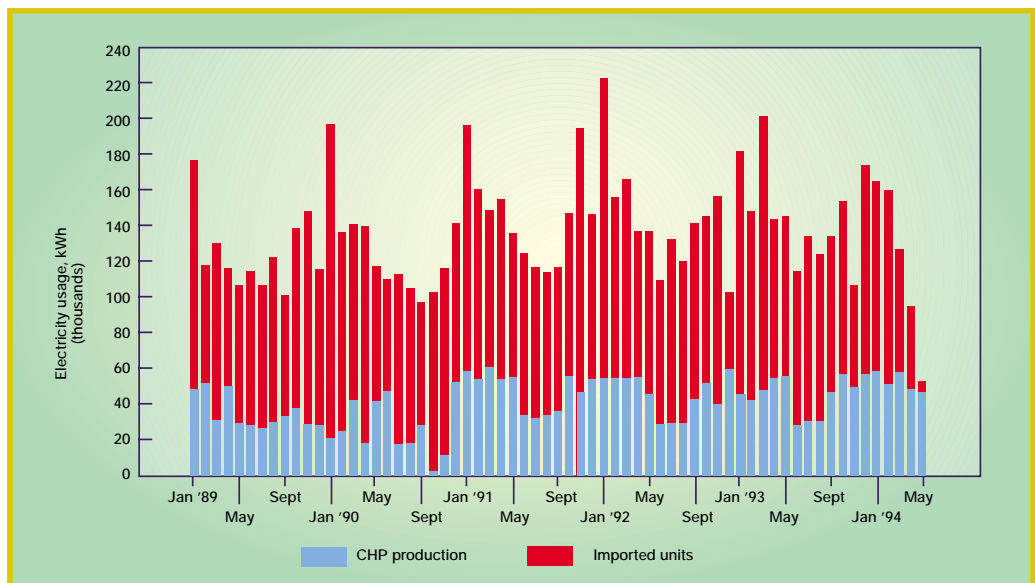


Fig 3 Site electrical usage

Engine components have experienced only normal wear and tear and have reached their specified life. Planned engine overhauls have been carried out. Essentially there are two types of overhaul: a top-end overhaul at 25,000 hours in which valve gear

and piston rings are replaced or re-seated; and a major overhaul at 40,000 hours in which bearings are replaced and piston/cylinder and valve gear are overhauled.

ECONOMIC ANALYSIS

Utilisation is normally defined thus:

$$\text{Utilisation} = \frac{R}{T} \times 100\%$$

Where: R = Annual hours run.

T = Annual hours that the CHP plant is designed to operate, assuming it is always available to do so.

CHP plant has to be maintained and, like any plant, breakdowns can occur. **Availability is normally defined thus:**

$$\text{Availability} = \frac{T - (S + U)}{T} \times 100\%$$

Where: S = Annual hours of scheduled maintenance shutdown.

U = Annual hours of unscheduled shutdown due to problems only with the CHP plant itself.

Note that these, and other similar terms, are sometimes defined in different ways. It is vital to understand exactly which definition is being used in a particular situation.

Top-end overhauls were carried out on both engines in 1989 at about 25,000 hours and major overhauls in 1991 at approaching 40,000 hours. In November 1994, Unit 1 had a top-end overhaul and Unit 2 had a major overhaul, both at 58,000 hours. Long-term maintenance costs have averaged around 1.2 p/kWh of electricity generated since commissioning of the plant.

ECONOMIC ANALYSIS

Under the Energy Services arrangement the service company provided the capital for the initial installation and undertook to maintain the plant throughout the ten-year contract¹. The Energy Services company charges the hospital a unit rate for heat and a unit rate for electricity, irrespective of whether the energy comes from the CHP plant, the boilers, or is imported. If the annual electricity consumption of the hospital is above approximately 1.3 MWh, the additional units are charged at a slightly higher rate.

The installation reached breakeven point, and started to make profit, in December 1988 after 38

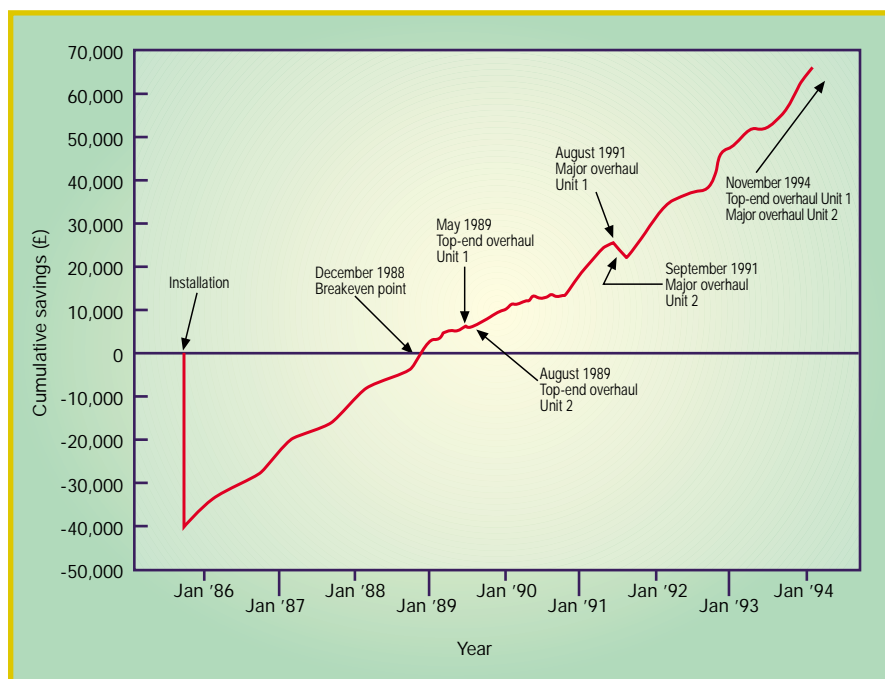


Fig 4 Cumulative savings achieved by the CHP plant

¹ Good Practice Case Studies 292 and 298 detail CHP schemes under capital purchase arrangements.

FUTURE CHP DEVELOPMENTS

Table 2 CHP energy and cost savings

| | Average/year | Over 8.4 years (Nov 1985 - Mar 1994) |
|---------------------------------------|----------------|---|
| Savings | | |
| Electricity generated | 521,800 kWh | 4.4 GWh |
| Value of electricity generated | £25,900 | £217,900 |
| Value of heat generated | £17,700 | £148,300 |
| Costs | | |
| Maintenance | £6,300 | £53,700 |
| Gas consumption | £24,800 | £208,200 |
| Net savings | £12,500 | £104,300 |
| Capital cost | | £40,000 |
| Actual breakeven | | 3.2 years |
| Simple payback on average performance | | 3.2 years |

months of operation (see Table 2 and Fig 4). Cash flow has remained positive since that date and total cumulative savings for the project to March 1994 stood at £64,300. Based on its share of the saving, it is estimated that the Energy Services company recovered its original investment in around 4.2 years. Savings for the hospital were immediate since it had no capital outlay.

FUTURE CHP DEVELOPMENT WITHIN THE HOSPITAL

The success of the 1985 installation has led the hospital to install a further CHP unit. This new plant is rated at 70 kW_e and serves a new wing and part of one of the old wings. The plant was partly funded by a grant from the Energy Savings Trust under its now completed Residential CHP Programme. The remainder of the capital cost was met under an equipment supplier finance (ESF) contract whereby the supplier installs, operates and maintains the CHP plant. The hospital just pays for

the electricity produced by the plant (at a lower rate than from the local electricity company) and for the gas consumed.

RELEVANT PUBLICATIONS

Good Practice Case Study 292, *Long-term operation of combined heat and power in university halls of residence.*

Good Practice Case Study 293, *Long-term operation of combined heat and power in a hotel.*

Good Practice Case Study 298, *Long-term operation of combined heat and power in a leisure centre.*

Good Practice Guide 226, *The operation and maintenance of small-scale combined heat and power.*

Copies of these publications can be obtained, free of charge, from ETSU or BRECSU.

The Department of the Environment, Transport and the Regions' Energy Efficiency Best Practice Programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry, transport and buildings. The information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice Programme are shown opposite.

Further information

For buildings-related topics please contact:
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Tel 01923 664258
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For industrial and transport topics please contact:
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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R & D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.